Apr. 18, 1951

UNITED STATES DEPARTMENT OF AGRICULTURE
U.S. SOIL CONSERVATION SERVICE
DIVISION OF IRRIGATION

14th annual meeting

MINUTES OF MEETING
COLUMBIA RIVER BASIN WATER FORECAST COMMITTEE

Held at Victoria, British Columbia, April 18, 1951

ATTENDANCE
FOURTEENTH ANNUAL MEETING
COLUMBIA RIVER BASIN WATER FORECAST COMMITTEE

Anderson, Bernard A.	Unknown
Anderson, Daniel G.	U. S. Geological Survey, Tacoma, Washington
Banks, F. A.	U. S. B. R., Grand Coulee Dam, Washington
Bartholet, Chas. J.	Washington Supervisor of Hydraulics, Olympia, Washington
Berry, W. H.	Engineering Secretary, Prairie Provinces Water Board, Regina, Saskatchewan
Blanchard, F. B.	East Bay M. U. D., Oakland, California
Brumley, D. J.	Atomic Energy Commission, Richland, Washington
Brundage, Eric C.	Seattle City Light, Seattle, Washington
Church, Phil. E.	University of Washington, Seattle, Washington
Clyde, George D.	Chief, Division of Irrigation, Soil Conservation Service, Logan, Utah
Codd, Ashton R.	Division of Irrigation, Montana State College, Bozeman, Montana
Conway, R. H.	Walla Walla District, Walla Walla, Washington
Cooper, A. C.	International Pacific Salmon Fisheries Commission, New Westminster, B. C.
Criddle, Wayne D.	Project Supervisor, Soil Conservation Service, Boise, Idaho
Dahl, Robert,	Hetch Hetchy Water Users, City of San Francisco, California
Ellison, E. C.	U. S. Weather Bureau, Portland, Oregon
Farrell, James W.	U. S. Forest Service, Portland, Oregon
Faulkner, C. F. P.	Dominion Dept. of Public Works, New Westminster, B. C.
Frame, S. H.	2660 Dufferin St., Victoria, B. C.
Frost, W. T.	Oregon Cooperative Snow Surveys, Medford, Oregon
Fryers, Walter	Meteorological Division, Dept. of Transport, Regina, Saskatchewan
Gregg, T. S.	Bonneville Power Administration, Portland, Oregon
Hafterson, Harold D.	2409 - N. 21st. Boise, Idaho
Hatt, Ellis L.	Soil Conservation Service, Portland, Oregon
Hill, W. A.	Washington Water Power Co., Spokane, Washington
Johnson, Oliver	Hydrology Section, Portland, Oregon
Johnson, Walter E.	Hydrology Engineer, Spokane, Washington
Kidd, G. J. A.	Assistant Hydraulic Engineer, Water Rights Branch, Victoria, B. C.
Klein, George	Division of Mechanical Engineering, National Research Council, Ottawa, Canada
Koelzer, Victor A.	U. S. Bureau of Reclamation, Denver, Colorado
Kramer, Harry A.	General Electric Company, Richland, Washington
Kulp, Mark R.	Reclamation Engineer, Boise, Idaho
Lang, W. A.	Southern California Edison Co., Los Angeles, California
Latham, Gus	Marshall Pass, Colorado

Leach, T. A. J.	Chief Hydraulic Engineer, Water Rights Branch Victoria, B. C.
Lockie, P. R.	Powell River Company, Powell River, B. C.
Maca, Leon F.	Engineering & Resources Branch, Dept. of Resources and Development, Vancouver, B. C.
MacLean, Duart A.	Water Rights Branch, Dept. of Lands and Forests, Victoria, B. C.
McNabb, E. C. B.	Acting District Engineer, Canadian Pacific Railway Co., Vancouver, B. C.
McCauley, A. P.	Officer-in-Charge, Meteorological Office, Dept. of Transport, Vancouver, B. C.
McDonald, C. C.	Staff Engineer, U. S. Geological Survey, Tacoma, Washington
McLeod, J. D.	Engineering & Resources Branch, Dept. of Resources & Development, Vancouver, B. C.
Monson, O. W.	Montana Agricultural Experiment Station, Bozeman, Montana
Murphy, F. C.	Corps of Engineers, Seattle, Washington
Nelson, Morlan W.	Snow Survey Leader, Soil Conservation Service, Boise, Idaho
Oliver, Harry W.	Pacific Gas & Electric Co, San Francisco, California
Paget, A. F.	District Engineer, Water Rights Branch, Victoria. B. C.
Pederson, C.	Corps of Engineers, Portland, Oregon
Poterson, Ben L.	Corps of Engineers, Portland, Oregon
Piper, Arthur M.	Staff Scientist, U. S. Geological Survey, Portland, Oregon
Polos, Anthony J.	U. S. Weather Bureau, Portland, Oregon
Posz, H. M.	Bureau of Reclamation, Sacramento, California
Purcell, Ralph	Fraser River Basin Board, Victoria, B. C.
Reynolds, Robin	Division of Water Resources, Sacramento, California
Riggs, H. C.	U. S. Geological Survey, Tacoma, Washington
Rupp, Vernon W.	U. S. Weather Bureau Office, Sacramento, California.
Sachs, Milton S.	Bonneville Power Administration, Portland, Oregon
Schaefer, Vincent J.	Research Laboratory, General Electric Company, Schenectady, New York
Searle, C. R.	Capt., Area Intelligence Officer, B. C. Area Canadian Army, Vancouver, B. C.
Simons, W. D.	U. S. Geological Service, Tacoma, Washington
Stockwell, Homer J.	Colorado Agricultural Exp. Sta. Fort Collins, Colorado
Strauss, Fred A.	Division of Water Resources, Sacramento, California
Templeton, G. W.	Powell River Co., Powell River, B. C.
Throckmorton, J. R.	U. S. Geological Service, Tacoma, Washington
Tredcroft, E. H.	Comptroller of Water Rights, Water Rights Branch, Victoria, B. C.
Veatch, F. M.	Dist. Engineer, U.S.G.S., Tacoma, Washington
Warnick, C. C.	Research Asst. Professor, Engineering Exp. Sta. University of Idaho, Moscow, Idaho
Webb, C. E.	Dist. Engineer, Water Resources Division, Dept. of Resources & Development, Vancouver, B
Wilm, H. G.	U. S. Forest Service, Portland, Oregon
Work, R. A.	Research Project Supervisor, Federal Cooperative Snow Surveys, Medford, Oregon

FOURTEEN ANNUAL MEETING
COLUMBIA RIVER BASIN WATER FORECAST COMMITTEE
Victoria, B.C.
April 19, 1951

Mr. C. E. Webb, District Engineer, Engineering and Water Resources Branch, Department of Resources and Development, Vancouver, B. C. called the meeting to order as presiding Chairman. He then introduced Mr. E. H. Tredcroft, Comptroller of Water Rights, Water Rights Branch, Department of Lands and Forests, Victoria, B. C. who gave an Address of Welcome to the delegates attending the Fourteenth annual meeting of the Columbia River Basin Water Forecast Committee.

The remaninder of the program was in three major sections with subjects and personnel introduced by Mr. Webb as follows:

CONDITIONS AFFECTING RUNOFF

Precipitation Conditions in Columbia Basin Since October 1st, 1950 by Anthony J. Polos, United States Weather Bureau.

You are all probably aware that precipitation at different times during the water year has varying effectiveness in producing runoff. For example, one inch of precipitation in September doesn't produce as much runoff as one inch in March. Because of this fact, precipitation will be presented not as a total value to date but as accumulated amounts for 3 separate periods. These periods are: (1) Spring or melt season, beginning with March; (2) Winter or the snow accumulation period, December through February; and (3) Fall or the soil priming period - September, October and November. The accompanying 3 maps are generalized pictures of the precipitation for each period, expressed in percentage of individual station averages.

FALL

Precipitation early in the water year was generally normal or above except for an area in Eastern Oregon south of the Wallowa Mountains, and then eastward along the Snake to Rexburg. In this area, individual reports of Fall precipitation are as low as 30% of station averages. However, there were large portions of the Basin which had greater than 150% of normal Fall precipitation. These areas include the Cascades, the Bitterroots, the headwaters of the Boise and Salmon Rivers, and the Continental Divide in Wyoming and from Summit to Banff.

WINTER

Precipitation during December, January and February followed a pattern similar to that of the Fall period but with generally less widespread areas of extreme values. The Cascade and Bitterroot Mountain areas, plus the Canadian area below Revelstoke-Banff again received well above normal precipitation. The Wallowa Mountain area which was deficient in Fall precipitation continued so in this period with the South Fork Clearwater and Lower

Salmon areas also slightly below normal. Individual values of Winter precipitation in the Lost River drainage of the Snake River were as low as 40% of station normals.

SPRING

Last month's precipitation was quite variable with the eastern slope of the Cascades and western portion of the Canadian drainage continuing to have greater than normal precipitation. In general, the Columbia drainage in Idaho and Western Montana had less than normal rainfall except for the Continental Divide in Montana and the Upper Payette and Boise Rivers. A broad strip from Kalispell to Clarkston averaged about 60% of normal March precipitation. Also in the Canadian portion of the Basin north of Revelstoke-Banff precipitation was less than 50% of the monthly normal. Almost the entire March precipitation occurred before the 16th of the month with no significant amounts for the rest of the month except for showers on the 27th and small amounts of rain on the 30th. During the first 15 days of April, the entire Basin was deficient of precipitation as little or no rain has fallen at the 30-odd stations in the United States and Canada from which we have received reports.

Streamflow Conditions in Columbia Basin Since October 1st, 1950 by J. D. McLeod, Department of Resources and Development, Vancouver, B. C.

During the period October 1, 1950, to March 31, 1951, precipitation was generally above average over the province. Deeper than normal snowfall was general throughout much of the province, particularly in the Columbia and Kootenay areas. However, since March 1 the snow cover in the latter areas has dropped from about 60% above normal on March 1 to about 30% above normal on April 1.

Temperatures during the period were slightly below normal. In February there was a period of above normal temperature which caused record run-off for that time of year at Wardner and Birchbank. At the beginning of March this condition changed rapidly to a period in which temperatures were from 10 to 20 degrees below normal. However, these returned to normalcy by the middle of March and have continued so since that time.

These conditions would indicate that a definite flood potential exists in the basin. The possibility of flood occurrence is almost entirely dependent upon temperatures occurring from now through May.

Lake levels indicate that surface reservoirs are at normal levels for this date. Streamflow in the Columbia Basin has been above average throughout the period, reaching a peak percentage of normal in February.

In the Upper Columbia River Basin the typical streamflow station is located at Nicholson, near Golden. Drainage area is 2,570 square miles. Precipitation at Golden for the six months period ending March 31 was 118% of normal and Nicholson run-off was normal. The minimum discharge occurred in January at a rate of 0.31 second-foot per square mile, compared with the recorded minimum of 0.16 second-foot per square mile in December, 1945.

In the Upper Kootenay River Basin the typical streamflow station is located at Wardner. Drainage area is 5,200 square miles. Precipitation at Cranbrook for the period was 185% of normal while discharge at Wardner was 130% of normal. The minimum discharge occurred in February at a rate of 0.23 second-foot per square mile, compared with the recorded minimum of 0.12 second-foot per square mile in January and March, 1914.

In the Lower Columbia River Basin the typical streamflow station is located at Birchbank, near Trail. Streamflow at this station is affected by the 110,000 acre regulated reservoir area of Kootenay Lake and the 95,000 acre unregulated reservoir area of the Arrow Lakes. Precipitation at Trail for the period was 145% of normal while run-off at Birchbank was 132% of normal, compared with 98% of normal for the period October 1, 1949, to March 31, 1950. The minimum discharge occurred in February at the rate of 0.59 second-foot per square mile compared with the recorded minimum of 0.26 second-foot per square mile in February, 1937. At March 31 the level of Kootenay Lake was 0.09 foot below normal and the level of Lower Arrow Lake was 0.04 foot below normal.

During the month of March 1951 the run-off at Birchbank increased to 144% of normal. The mean flow was 25,900 second-feet compared with the long-term mean of 18,000 second-feet. The mean flow for March 1950, 16,900 second-feet, was 94% of the long-term mean. On March 31, the discharge was 23,400 second-feet compared with 13,500 second-feet on March 31, 1950.

One of the more important of the numerous tributaries of the Columbia River system which rise in Canada and enter the main stem in the United States is the Okanogan River. This river is the outlet of Okanogan Lake, a regulated reservoir of 84,200 acres. Run-off of the Okanogan River at Penticton with a drainage area of 2,340 square miles for the six months period ending March 31, 1951 was 156% of normal compared to 123% of normal for the same period last year. The minimum discharge occurred in February at the rate of 0.09 second-foot per square mile, compared with the recorded minimum of 0.00 second-foot per square mile in January 1932 and January 1950. The discharge on March 31, 1951, was 749 second-feet compared with 754 second-feet on March 31, 1950. The level of Okanogan Lake on March 31, 1951, was 0.02 foot below normal compared with a level of 0.09 foot below normal on March 31, 1950.

<u>Run-off Conditions in State of Washington For Period October 1950 to March 1951, Antecedent to The April 1, 1951 Snow Surveys and Remainder of The Water Year 1951, by Fred M. Veatch, District Engineer, U.S.G.S.</u>

Streamflow records collected at several index gaging stations in Washington show that this year's antecedent run-off is extremely high. It is much greater than for any of the past four years and is roughly twice the 25-year average. February was the highest month, or about three times the normal. Every month of the six was well above average. Following are the detailed data supporting the above statements:

Discharge October 1, 1950 to March 31, 1951

Columbia River at Grand Coulee

Month	Mean (1950)	Median (1921-1945)	% of Median
October	61,590	49,000	126
November	67,260	43,500	155
December	68,750	36,300	189
January	74,490	34,800	214
February	88,930	33,800	263
March	68,660	39,000	176
Period	71,350	40,000	178

Spokane River at Spokane

October	2,631	1,400	188
November	5,148	1,780	289
December	10,050	3,150	319
January	7,758	3,100	250
February	16,200	4,150	390
March	7,636	7,100	108
Period	8,123	3,444	236

Comparison October to March run-off 1,000 Acre-feet for last four water years.

River	Drainage area	1948	1949	1950	1951	25-year Ave. 1921-1945
Columbia River at Grand Coulee	74,100	22,119	16,199	18,371	25,760	14,500
Snake River at Clarkston	103,200	13,044	12,685	12,022	16,094	*
Spokane River at Spokane	4,350	2,112	1,586	2,286	3,029	1,463
South Fork Skykomish nr. Index	355	872	624	989	1,176	769

* No consecutive 20 or 25-year period available for computing long-term average.

Streamflow in Oregon During the 1950-51 Water Year, by K. N. Phillips, District Engineer, U. S. G. S.

The Portland office of the U. S. Geological Survey computes records on a current basis at three gaging stations which serve as an index of streamflow in Oregon. These stations are Columbia River near The Dalles, John Day River at Service Creek, and Umpqua River near Elkton. All three of these stations averaged above median during each month of the water year to date.

For Columbia River near The Dalles, monthly discharge ranged from 132% of median in October to a high of 234% of median in February. For the six-month period the flow averaged 171% of median with a total run-off of 54,130,000 acre-feet.

At John Day River at Service Creek the range was from 136% of median in March to 358% of median in December. Total run-off for the period was 866,700 acre-feet or 221% of median. The run-off in February was the highest ever recorded for that month in a 23-year period of record. This was largely the result of an earlier than usual snow melt in this basin. New daily highs for their respective months were registered in October and February.

At Umpqua River near Elkton the range in monthly flows was from 128% of median in March to 1,160% of median in October, while for the period the run-off was 6,741,000 acre-feet or 215% of median. The unusually large value for October, which was a new high for that month in a 46-year period of record, was caused by the flood which occurred in southwestern Oregon at the end of the month. At this station the peak was the highest in the period of record and was only about 1 foot below the maximum known stage (that of 1861) at this site.

So far in April these streams are still running above normal. However, many of the streams in Oregon where snow melt is no longer a factor are now running at below normal levels as a result of the prolonged dry spell which began about the middle of March.

Streamflow Conditions in the Columbia River Basin in Montana Since October 1, 1950, by Frank Stermitz, District Engineer, U. S. G. S., Helena, Montana.

The run-off during the period October 1, 1950 to March 31, 1951 has been unusually high in the Columbia River drainage basin in Montana. Streams were at relatively high levels at the beginning of the period and have generally remained so under favorable conditions of temperature and precipitation. A general rise occurred in late December following warm rains that were most pronounced in the northern portion of the area. Another rise about February 10 to 13 was the result of unseasonably warm weather. The latter caused some flood damage at Kalispell and Libby through rapid run-off from snow melt in minor tributary basins. Contrary to usual trends March run-off was much less than that of February. Relatively cold weather during March and the February melt are judged to be the causes. Ice effect was minor in the past winter season and was most pronounced in December and mid-March.

Comparative data is available for four streams where the effects of storage or regulation is of little consequence. Records for approximate 20 year periods beginning about 1929 have been used in order to maintain a fairly uniform basis for comparison. The relative variations of monthly mean flows to 20-year medians is fairly well illustrated by the following comparison of the flow of the Flathead River at Columbia Falls, Montana: October 6,372 c.f.s., 274 percent of median; November 6,781 c.f.s., 266 percent of median; December 6,938 c.f.s., 325 percent of median; January 4,601 c.f.s., 240 percent of median; February 5,908 c.f.s., 318 percent; March 3,274 c.f.s., 145 percent. The relation of cumulative flows for the period October 1, 1950 to March 31, 1951 to median flows for equivalent periods of the past 20 years are given: Flathead River at Columbia Falls, 238 percent of cumulative median; South Fork of Flathead River near Columbia Falls, 239 percent of median; Kootenai River at Libby, 172 percent; Clark Fork below Missoula, 164 percent.

Antecedent Streamflow in Columbia Basin as it May Affect Run-off Forecasts for 1951, by Thomas R. Newell, District Engineer, Boise District, U.S.G.S. Boise, Idaho.

The following memorandum is limited to reporting on streams in Boise district which comprises roughly all of Idaho except upper Snake River (above Milner). Streamgaging in the upper Snake or Water District 36 area is done by the Idaho Falls district office.

Antecedent flows are of significance in forecasting subsequent run-off magnitudes. For application to the 1951 forecasts the antecedent period October 1, 1950, to March 31, 1951, is featured and comparisons with flows for the corresponding period during past years are shown.

Streamflow has been above normal in Idaho for the antecedent period. In the overall view, larger flows have been recorded for the northern Idaho streams than for those in southern Idaho, relative to normals. On a seasonal basis, run-off in the north reflected heavy rains during the fall months, and some unusual peaks were recorded during February. Flows during March 1951, were generally less than during March 1950. During the antecedent period, releases from American Falls Reservoir were larger than a year ago and are reflected in larger winter flows in middle and lower Snake River. Judging from Mr. Crandall's weekly advices, Snake River flow passing Milner Dam has averaged some 5,000 second-feet greater January-March 1951, than for January-March 1950. The increases in north Idaho streams during late December and unusual maximums of February 11, 12 are worthy of note. Local floods in February were experienced on Raft River, Shoshone Creek and Jordan Creek in southern Idaho. Otherwise the antecedent run-off in Idaho may be said to have followed an orderly pattern.

Monthly flows in comparison with median flows are shown for Salmon River at Whitebird, Idaho (flows are in second-feet).

Month	Mean flow	Median flow	Per cent of Median
October 1950	6,309	4,020	157
November 1950	7,120	4,240	168
December 1950	5,754	3,890	148
January 1951	4,695	3,530	133
February 1951	5,917	3,820	155
March 1951	5,414	4,610	117

Runoff for the six-month period is shown in comparison with corresponding run-off during each of three preceding years and the 20-year average for seven representative streams in Boise district. These provisional run-off figures are given in thousands of acre-feet for the October to March period.

Comparison antecedent period run-off, Idaho Rivers

River	Drainage area	1947-48	1948-49	1949-50	1950-51	Average 1930-49
Kootenai, Leonia	11,740	2,738	1,501	1,850	3,046	1,707
Clark Fork, Heron	21,800	5,487	3,882	4,770	6,786	3,534

Comparison antecedent period run-off, Idaho rivers, (Cont'd.)

River	Drainage area	1947-48	1948-49	1949-50	1950-51	Average 1930-49
St. Joe, Calder	1,080	496	280	490	764	404
Clearwater, Spalding	9,570	3,809	2,616	3,276	4,316	2,644
Salmon Whitebird	13,500	1,845	1,717	1,622	2,116	1,542
Payette Horseshoe Bend	2,230	*	434	511	645	462
Boise, Diversion Dam	2,650	364	385	447	553	410

* Bureau of Reclamation regulation at Cascade Reservoir uncertain.
Clark Fork figures are not adjusted for upstream storage.
Payette and Boise figures are adjusted for upstream storage.

Status of Ground-Water Storage as Shown by Index Wells in the Columbia River Basin of Washington, Oregon and Northern Idaho, April 1, 1951, by R. C. Newcomb, and F. A. Watkins Jr. U. S. G. S.

The well measurement net of the Ground Water Branch of the Geological Survey in Oregon, Washington, and northern Idaho is composed of observation wells principally located in the valleys of the major streams. Most are privately owned wells. Each well was selected for measurement because it represented ground-water level in a particular geologic or hydrologic unit of the Columbia River basin.

Observations on ground-water levels are taken with tape gage, automatic water-stage recorder, or hand tape measurements. Several of the wells now used have been measured periodically for over 20 years, the average is about 16 years.

The coverage is fairly good in the valleys and plateaus of the downstream part of the Columbia River drainage basin, but it does not reach into the mountainous uplands from which snow fields furnish the bulk of the flood component of the Columbia River, either to obtain data on ground-water levels or to evaluate the percolation conditions of the soil and rock materials.

A beginning is being made in getting observations on ground water in the upstream and mountain areas. It is intended to progressively improve this net without at this time digressing into the vast field of ground-water hydrology in mountainous areas.

Though the mountain storage and infiltration capacities are not evaluated directly by our observation-well net, the other principal factors of bank storage and of ground-water levels in the lower river tributary areas are represented. In the use of these water-level observations the lowest and highest ground-water levels of record are taken to establish

the range and the median point (or 50 percent above the lowest of record) is called the normal ground-water condition. The yearly levels as of April 1 are expressed as a percentage of this range above the lowest of record.

Within the tributary valleys of the Columbia the observed levels indicate that the following conditions prevail: In the Rathdrum Prairie extension of the Spokane Valley northward to Pend Oreille Lake the ground-water level is high, in the upper fourth of the record. In lower Spokane Valley to the falls at Spokane it stands at about the average or mean condition. In the Palouse drainage basin where ground-water levels reflect antecedent soil-moisture absorption, the ground-water levels are high, in or near the upper fourth of the record. In the Walla Walla Valley, where ground-water levels in large part reflect absorption of run-off from mountainous areas, the levels are down -- below the median point. In the valley of the Okanogan River the water levels are low, among the lowest fourth of the record. In the Big Bend area on the Columbia plateau surface itself the underflow through the glacial outwash gravels of the upper Crab Creek Valley are high, in the upper fourth of record.

Over all, the ground-water levels -- which at this time last year stood exceedingly high, mostly at or near the highest of record -- now stand at an average height of about median stage of the recorded range. Such a condition indicates that, in general in these more or less middle-of-the-basin areas, considerable storage space is available now and will probably be present later this spring to help alleviate flood discharges in the Columbia Basin.

Storage index for selected wells in the Columbia Basin

Well*	Location	Length of record (yrs)	Index in percent of the total observed range above lowest water level of record		
			April 1949	April 1950	April 1951
50/5W-1A1	Rathdrum Prairie, Ida., near Post Falls	22	70.7	80.4	84.4
51/5W-33D1	do., Grand Junction	23	82.7	100.0	87.0
53/4W-24D1	do., near Athol	23	85.3	90.5	90.6
25/42-14L1	Spokane Valley, Wash., at Riverside Cemetery	11	49.4	62.4	48.7
25/44-15E1	do., near Opportunity	38	33.9	65.3	55.5
25/44-22N1	do. do.	8	37.5	--	--
25/45-16C1	do., near Greenacres	23	79.3	100.0	68.5

Storage index for selected wells in the Columbia Basin. (Cont'd.)

Wells*	Location	Length of record (yrs.)	Index in percent of the total observed range above lowest water level of record		
			April 1949	April 1950	April 1951
26/43-19A1	do., North of Spokane	21	41.8	60.9	55.6
19/28-22G1	Columbia Basin Project area, Wash., at Moses Lake	8	83.2	--	--
22/27-30P1	do., at Grants Orchards	12	48.1	74.8	well pumping 87.0
22/28-6R1	do., near Stratford	11	--	86.4	--
34/26-26Q1	Okanogan Valley, Wash., at Omak	12	24.7	23.3	25.1
40/27-28G1	do., at Oroville	12	29.0	16.5	24.2
14/45-11N2	Palouse Valley, near Pullman	15	--	92.8	89.1
15/46-20K1	do.	15	--	99.5	100.0
6N/35-36H1	Walla Walla Basin Milton	16	52.7	73.6	36.5

* Well numbers are derived from the system of public land surveys. Thus, 25/42-14L1 is in T. 25 N., R. 42 E., sec. 14 - Willamette Base and Meridian. Similarly, wells in Idaho are located with reference to the Boise Base and Meridian. The location within the section is described in U. S. Geol. Survey Water-Supply Paper 990, p. 157, 1943.

RUNOFF AND PEAK FORECASTS

Snow Cover and Runoff Forecasts in Columbia River Basin for 1951:

British Columbia: Mr. Gordon J. A. Kidd, Water Rights Branch, presented the data and interpretation contained in the April report entitled "British Columbia Snow Survey Bulletin, For Columbia and Fraser Basins in British Columbia and Lower Coastal Areas". For details of this presentation please refer to that publication.

Snow Cover and Runoff Forecasts in Columbia River Basin for 1951. (Cont'd.)

Washington: Mr. Walter Johnson, Washington Water and Power Company.

The Washington Water Power Company is an electric service utility serving eastern Washinton and northern Idaho. The Company is a charter member of the Northwest Power Pool. Annual snow surveys are made in the Coeur d'Alene Lake Basin, which is the source of the Spokane River, and in the Lake Chelan Basin located on the east slope of the Cascade Mountains in north central Washington.

Our 1951 forecasts are as follows:

Spokane River

The average water content of nine snow courses in the Coeur d'Alene Basin as of March 15 was 24.8" which is 9% above the twenty-five year average.

Forecast run-off for the Spokane River at Post Falls for the period March 16 to September 30 equals 3.25 million acre feet. It is 8½% above the twenty-five year average of 3.0 million acre feet.

Based on a snow storage, expected rainfall, and average run-off rates, the peak discharge at Spokane will probably reach 26,000 cfs during the first decade in May. Yesterday's flow was 20,000 cfs.

This forecast was made over a month ago and since that time precipitation in the area has been practically zero. Should this condition extend into May the run-off forecast should be reduced.

Lake Chelan

The average water content of eighteen snow courses in the Upper Chelan area is 44.4", which is 43% above the twenty-one year average of 31.0".

Our forecast of total lake inflow for the period April through July is 1.26 million acre feet. It is 31% above the twenty-one year average of .964 million acre feet.

We forecast that .55 million acre feet or 17 feet of lake storage will be wasted during the period April through July. During February and March, 7½ feet of lake storage was wasted.

Again this year we plan to waste a relatively small amount of water over an extended period of time prior to reaching the maximum lake elevation on July 1st in order to eliminate any danger of high discharge breaking the dike between the tailrace and waste channels.

Speaking unofficially for the Northwest Power Pool, 1951 appears very good, in fact there have been ample water supplies now for six years. The critical period for the Pool is from October to March. To tailor make the coming run-off on the Columbia River, the Pool would like to have a flat peak to maintain high peaking capacities and a late run-off to retard the start of the storage season.

Last week the British Columbia Snow Bulletin, the Columbia Basin Snow Survey Report, and the Weather Bureau Forecast report together with the river discharges for the past six months arrived in our office. I was interested in the forecasts of the Columbia at the Border which includes the Upper Columbia, the Kootenay, and the Clarks Fork. Here are my results:

From the B. C. Snow Bulletin--

The average water content of 11 snow courses in the Columbia River Basin for 1951 equals 17.1"; for 1950 equals 16.1".

The average water content of 15 snow courses in the Kootenay River for 1951 equals 21.8"; 1950 equals 23.9".

The average water content of 53 snow courses in the Clarks Fork Basin for 1951 equals 25.5"; 1950 equals 29.3".

My composite average for 1951 equals 21.5; 1950 equals 23.1. 1951 is 7% less than 1950.

Switching to the Weather Bureau Forecast, I was startled when I read that the yearly forecast for the Kootenay River at Leonia was 179% of normal and the Clarks Fork at Heron was 167% of normal and the Columbia River at Birchbank, which includes the Kootenay, was 122% of normal.

Here are last year's forecasts by the Soil Conservation Service and the Weather Bureau:

Columbia River at Birchbank	SCS	equals	45.0 MAF	actual
	WB	"	46.2 MAF	45.4 MAF
Clarks Fork at Heron	SCS	"	16.9 MAF	
	WB	"	13.5 MAF	16.9 MAF

For this year:

Columbia River at Birchbank	SCS	equals	52.0 MAF
	WB	"	46.1 MAF
Clarks Fork at Heron	SCS	"	12.1 MAF
	WB	"	12.3 MAF
(Combined)	SCS	"	64.1 MAF
	WB	"	58.4 MAF

(WB 9% less than SCS.)

The Soil Conservation Service forecast at Birchbank of 52 MAF, appears high, last year they forecast 45 MAF.

In conclusion, there appears to be a well-defined relationship between precipitation, accumulated snow storage, and run-off in the Upper Columbia Basin.

Montana: A. R. Codd, Soil Conservation Service. For details of this presentation please refer to the April report, entitled "Federal-State Cooperative Snow Surveys and Irrigation Water Forecasts for Montana and Northern Wyoming Upper Missouri, Upper Columbia and Yellowstone Rivers."

Oregon, Nevada: W. T. Frost, Soil Conservation Service, Oregon. For details of this presentation please refer to the reports entitled, " Federal-State Cooperative Snow Surveys and Irrigation Water Forecasts for Nevada." (April Reports) and to "Federal-State Cooperative Snow Surveys and Irrigation Water Forecasts for Oregon."

Idaho and Wyoming: M. W. Nelson, Soil Conservation Service, Boise, Idaho. For details of this presentation please refer to the April report entitled " Federal-State Cooperative Snow Surveys and Irrigation Water Forecasts for Columbia Basin."

Forecasts of Runoff and Peak Stage of the Columbia River At The Dalles, by Anthony J. Polos, United States Weather Bureau.

Total water year runoff forecast as of April 1, 1951 for The Dalles is 154,000,000 acre feet, assuming normal precipitation for the remainder of the water year. As of April 17, approximately 62,000,000 acre feet has passed The Dalles, leaving approximately 92,000,000 acre feet. On this basis, we have revised our April 1, 1951 forecast of the peak flow at The Dalles from 600,000 c.f.s. to 560,000 cfs, or a stage of 23.5 feet at The Dalles. A peak flow of 560,000 cfs would result in a stage of from 18.5 to 19.5 feet at Portland and Vancouver Harbors. A further review and discussion of these peak flow estimates will appear in the May 1st Water Supply Bulletin, and will be followed by short range forecasts issued through the Weather Bureau's River District Offices in Portland, Spokane and Boise.

Forecasts of Runoff and Peak Stage of The Columbia River At The Dalles, by Clarance Pederson, United States Corps of Engineers, Portland, Oregon.

The potential flood situation on Lower Columbia River is somewhat relieved from that of the past three years in spite of the above normal water content of the April 1 snow pack. This optimistic outlook can be attributed to weather conditions that have prevailed throughout the Columbia River Basin during the past months. Temperatures have been above normal, resulting in an early melt of some of the low elevation snow. This reduces the available supply and areal coverage that can contribute to the basin run-off at the time of the flood crest. Precipitation has been below normal since the middle of March, a climatic condition that reduces the volume of the flood based on April 1 snow reports. This combination of higher than normal temperatures and below normal precipitation is conducive to a reduced flood potential, particularly if the below normal precipitation continues through April and May.

This optimistic flood forecast, however, is not intended to create complacency, as weather conditions can change fast and create a more serious flood outlook; but the probability of such a change in the weather that would give rise to a serious flood potential is decreasing as each day of the present weather prevails.

Other areas within the Columbia River Basin undoubtedly will not fare as well as the Lower Columbia River below the confluence with Snake River, particularly the lower reaches of those streams heading in Canada. Major floods are quite probable on the Kootenai and Okanogan Rivers. Lesser flooding will occur on a number of the other tributaries as a normal high water can be expected throughout the Columbia River Basin.

At The Dalles on Columbia River, it is forecast that the April-September run-off will be 105,000,000 acre-feet; and the peak discharge will be 625,000 second-feet before regulation by upstream storage.

On the basis of past experience Grand Coulee and other incidental storage regulation should reduce this flow approximately 40,000 second-feet, which is equivalent to a one-foot reduction in stage in the Vancouver-Portland area. In 1948 and 1950 the observed peak discharge at The Dalles was 1,010,000 second-feet and 743,000 second-feet, respectively.

The 1951 forecast peak flow in terms of gage height at Vancouver and Portland is 22.3 feet and 21.9 feet, respectively. These stages are in excess of flood stage at their respective stations in the amount of 7.3 feet at Vancouver and 3.9 feet at Portland. Flood damages on the Lower Columbia River are not serious until the stage at Vancouver exceeds 26.5 feet, as most of the developed areas are protected by levees for floods of lesser magnitude. The 1951 flood would have to exceed the forecasted peak by 175,000 second-feet at The Dalles before serious trouble would develop.

As to when the crest stage can be expected on the Lower Columbia River, it is entirely dependent upon weather conditions during the next two months. The most probable date would be June 7. Current weather conditions are conducive to an early flood crest this year, provided the weather continues to remain consistently above normal between now and May 15. A temperature sequence of this order augmented by precipitation in May could produce a higher peak discharge than forecast. April 1 forecasts are two months in advance of the average flood crest, and are subject to considerable error should the weather during the intervening months deviate greatly from normal. For this reason, April 1 forecasts should be considered tentative and subject to revision as the flood season develops.

Forecasts for April-September run-off and peak discharge for several pertinent stations on Columbia River and tributaries are shown on the attached tabulation.

Western Washington Snow Survey Results by Unites States Geological Survey, 1951, by Daniel G. Anderson, Hydraulic Engineer, Tacoma, Washington.

The United States Geological Survey measured 25 snow courses in western Washington during the first of April snow surveys. All, except 3 courses on the Olympic Penninsula, were located on the west side of the Cascade Mountains.

The weather has been very unusual in western Washington during the past winter as evidenced by the March and April snow surveys. Heavy rains of February 9, 10, and 11 extended to elevations of about 6,000 feet in some areas; however, we have good evidence that in other areas during that storm only snow fell down to elevations of 3,000 feet. This and other unusual conditions have caused a number of poor correlations between snow survey results, not only between individual courses but also between entire basins. It will be better to discuss the area as a whole rather than the isolated cases.

On the first of April snow surveys the low elevation courses showed less water in comparison with past years than did the higher elevation courses. This year the water stored in form of snow below 4,000 feet is

1951 RUN-OFF FORECASTS
COLUMBIA RIVER BASIN

Corps of Engineers — 7 April 1951

Stream	Station	Water content-Apr.1 snow pack %normal 1/	1951 Forecasts: Apr. - Sept. run-off: Acre-feet	% of normal 2/	Flood peak: Second-feet	Stage feet	Flood stage in feet 3/
Columbia River	Birchbank	128	44,000,000	116	260,000	37.0 2/	-
Do	Trinidad	125	72,000,000	115	425,000 4/	49.2	-
Do	Umatilla	125	-	-	605,000 4/	21.9	25.0
Do	The Dalles	125	105,000,000	116	625,000 4/	25.1	-
Do	Vancouver	125	-	-	-	22.3 4/	15.0
Kootenai River	Leonia	127	9,200,000	120	85,000	17.2	15.0
Pend Oreille R.	Metaline Falls	119	16,000,000	121	105,000	42.0	37.5
Okanogan River	Tonasket	137	2,000,000	133	20,000	15.6	14.5
Spokane River	Spokane	116	3,200,000	111	30,000	26.6	28.5
Yakima River	Kiona	134	1,700,000	132	15,000	10.5	10.5
Snake River	Heise	122	4,400,000	120	27,000	8.5	7.0
Do	Clarkston	125	27,000,000	136	230,000	32.6	39.0
Salmon River	Whitebird	131	7,200,000	117	75,000	28.8	-
Clearwater River	Spalding	120	9,000,000	115	115,000	18.4	17.0
Umatilla River	Pendleton	108	190,000	113	4,000	4.4	4.5
Willamette River	Portland 5/	-	-	-	-	21.9 4/	18.0

1/ Normal based on 13 to 15 years of snow survey records.
2/ Normal based on April-September run-off for period 1936-50.
3/ Flood stage is for the reach of river that uses that station as an index.
4/ Assuming no flood regulation at Grand Coulee. Based on experience, it is reasonable to assume Grand Coulee will reduce flood peak by at least 40,000 second-feet, which is approximately 1 foot in the Vancouver-Portland area.
5/ High water at Portland on Willamette River in May, June, and July is caused by backwater from Columbia River.

about 65% of that in 1950 and is about equal to the normal for the last ten years. However, above 4,000 feet we found about 90% of the 1950 quantities or 125% of normal for the last ten years. To further break down the 125%-of-normal figure, we find about 130% in the northern part and 115% in the southern part of western Washington. The snow line as of the first of April also varied from about 1,500 to 2,500 feet going from north to south.

This signifies a very good water supply outlook for western Washington in 1951. However, an earlier than normal runoff is expected because of the warm weather and lack of precipitation during the last three weeks, since March 29. This probably has hastened the snow on its way to the various reservoirs.

EFFECTS OF FORECASTED RUNOFF

General Discussion of Forecasts as related to the U. S. Bureau of Reclamation, by Harold D. Hafterson, Regional Hydrologist for the Bureau of Reclamation, Boise, Idaho.

The Bureau of Reclamation has long recognized the benefits of forecasting runoff in this area. Some of the earliest snow surveys in this region were initiated by the Bureau in the upper Snake River Basin in 1918 and 1919 for the purpose of assisting in forecasting the flow which would be available for irrigation. Forecasts have also been made for many years in the Boise and Yakima River basins for the same purpose.

More recently the increasing need for flood control has resulted in the development of multiple-purpose reservoirs. Their use for flood control and power as well as for irrigation has increased the Bureau's need for reliable forecasts of runoff. As yet, however, most of the 11 or 12 million acre-feet of active storage on Bureau of Reclamation projects in the Northwest has been authorized without specific provision for flood control use. In spite of this fact, through reliance on flood runoff forecasts, the Bureau of Reclamation, in collaboration with the Corps of Engineers, operated a considerable portion of this storage for flood control in 1949 and 1950 in such a manner as to avert substantial flood damage, estimated by the Crops of Engineers at some five and one half million dollars in 1950.

Forecast methods must be improved if such multiple-purpose operation is to be continued or extended to provide maximum benefits. In 1949, inaccuracies in all April 1 forecasts for the Boise River could have resulted in substantial loss of storage had our operators placed complete reliance in the then available forecasts and followed our proposed operating plans implicitly. For this reason we recommend that all agencies presently concerned with stream flow forecasting make every effort to refine their methods with a view to increasing the accuracy of their forecasts.

General Discussion of Forecasts as Related to the Bonneville Power Administration, by Milton Sachs, Chief, Water Utilization Section, Branch of Power Resources, Bonneville Power Administration, Portland, Oregon.

The Bonneville Power Administration has a direct interest in the

forecasts of volume runoff and of peak flow for rivers in the Pacific Northwest. Various forecasts were presented today by representatives of the United States Weather Bureau, Soil Conservation, Corps of Engineers and representative from the Water Rights Branch Canadian Department of Lands and Forests. These forecasts all indicate another spring and summer of ample runoff accompanied by a lower flood potential than that experienced during the past three years.

The interest of the Administration in spring and summer runoff forecasts is centered first, on the effect these forecasts have in the operation of Grand Coulee in the interest of flood control with a minimum loss to power; and secondly, the extent of reduction in power output at the Bonneville plant caused by a high tailwater elevation and as a result a reduced net power head. Consequently, the Bonneville Power Administration is interested in the development of forecast methods which would yield more accurate forecasts of streamflow during these spring and summer months.

Bonneville's chief concern, however, is for streamflow forecasts for periods of shorter duration which are not now available particularly during the critical storage drawdown period, October through March. These forecasts are required for scheduling reservoir operations and coordinating storage releases from Grand Coulee and Flathead Lake with tributary inflow between Grand Coulee and Bonneville in the interest of optimum water utilization for power production.

Daily, three-day, weekly, monthly, and longer periods of streamflow forecasts are urgently needed for the operation of Grand Coulee and Bonneville power plants during the critical water period of October through March. It is imperative that storage releases be based on reliable forecasts of inflow. Any miscalculation of forecasted inflow early in the season would result in an unnecessary loss of head. This loss of head would continue throughout the season with great damage to power. The need for these short-range forecasts will further increase with the completion of Hungry Horse, Chief Joseph and McNary power plants.

To meet this need for short-range forecasting during the storage period this past winter, we made full use of our hydrologic network from which we obtain daily reports from 60 stream-gaging stations, 17 lake gages, and 17 precipitation and temperature stations. The daily reports from the gaging stations are obtained in cooperation with the U. S. Geological Survey, electric power utilities and from the Water Resources Division, Department of Resources and Development, in Canada. Precipitation and temperature reports are obtained daily from the Weather Bureau, Portland, Oregon.

Considerable success was attained during the past season in making short-range forecasts of periods of 30 days or less. Forecasts developed on the basis of current available streamflow were primarily for determination of minimum streamflow forecasts in the days, weeks, and months ahead. From these estimates of minimum streamflow during the critical storage period (October through March), we can determine in advance the loads which can be carried by the various Federal and non-Federal power plants in the region.

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These forecasts, in main, are based on recession and deplotion curves developed for each major power stream. Obviously, considerable difficulty is encountered in forecasting periods beyond 30 days. As is well recognized, it is very dangerous to attempt a forecast of runoff during the winter months since this runoff is largely affected by fluctuation due to precipitation, snowmelt, and freeze-ups over a more steady groundwater discharge.

The forecasts this past season were based on a combined statistical analysis of past streamflow conditions and forecast of minimum flow based on recession and depletion curves. The curves were derived from studies of hydrographs and hyetographs for past years selecting periods in the fall and winter with no precipitation. Those portions of hydrographs bearing the magnitude of streamflow desired were combined to form a recession and depletion curve for each stream. These were used in short-range forecasting for the next 30 days or less. For the period following, through the balance of the season, the statistical analysis was used to determine the minimum possible runoff from antecedent conditions exclusive of freeze-ups.

Since we experienced an abundance of water this past winter, the real test of the long-range winter forecasts has not been made. There is, of course, continuing need for further improvements in the forecasting procedures and technique for forecasting minimum runoff during the critical period. We are certain that the power year ahead will be very serious under minimum water conditions and median water conditions will be necessary if regional loads are carried. Every effort, therefore, will be made to obtain additional daily streamflow reports from key tributaries in order that uncontrolled inflow may be forecasted most accurately. It is apparent that arrangements will have to be made to receive current reports on snowfall in the lower elevations and snow water content in the upper elevations. Information regarding snow conditions on the upper tributary basins would be very useful if they could be obtained twice each month.

We are aware of the fact that much is yet to be accomplished towards developing forecasting techniques to realize the effective utilization of the Columbia Basin water resources for maximum power production. We further realize that there is much to be gained through the exchange of information and cooperation with other agencies in the advancement and evolution of the necessary procedures for making long-range, seasonal, and short-range forecasts.